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By-DRUKER, Joseph F.; Hagen, John W.

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The role of perceptual discrimination in the development of the ability to selectively process information was investigated. Using an incidental learning paradigm, the discriminability between relevant and irrelevant stimuli was experimentally varied in two ways: (1) contiguity versus non-contiguity in spatial arrangements and (2) alternating versus non-alternating arrangements. The subjects were 80 children in each of the fourth, sixth, and eighth grades. It was concluded that the development change responsible for selective information processing did not involve improved visual discrimination. A post-test questionnaire revealed that older subjects were characterized by more efficient encoding and rehearsal strategies which were postulated as the basis for the older subjects' relatively better ability to selectively process information. This paper comprises a report in "Development of Language Functions, A Research Program-Project (Study C: Development of Selective Attention Abilities)." (Author/DO)

The University of Michigan

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Abstract

The role of perceptual discrimination in the development of the ability to selectively process information was investigated. Using an incidental learning paradigm, the discriminability between relevant and irrelevant stimuli was experimentally varied in two ways: contiguity vs. non-contiguity in spatial arrangements and alternating vs. non-alternating arrangements. The Ss were 80 children in each of the fourth, sixth, and eighth grades. It was concluded that the developmental change responsible for selective information processing did not involve improved visual discrimination. A posttest questionnaire revealed that older Ss were characterized by more efficient encoding and rehearsal strategies which were postulated as the basis for the older Ss' relatively better ability to selectively process information.

Developmental Trends in the Processing of Task-relevant and Task-irrelevant Information

Joseph F. Druker[1] and John W. Hagen

University of Michigan

Previous research (Maccoby and Hagen, 1965; Siegel and Stevenson, 1966; Crane and Ross, 1967; Hagen and Sabo, 1967; Hagen, 1967) has consistently found that between the ages of 10-13 years children show marked improvement in the ability to select what is relevant from what is irrelevant in a learning situation. The results of these studies have been interpreted to indicate that young children's relatively inefficient performance in learning and perceptual tasks is partly due to their inability to focus attention on the relevant aspects of the task. Zeaman and House (1964) propose that mentally retarded children are slower than normals in discrimination learning because the retarded children are unable to attend to the relevant dimension, not because of an inability to approach the correct cue of the dimension.

Previous studies in this area have used stimuli composed of displays of spatially contiguous pictures. The E designates one picture as the central or task-relevant stimulus and instructs S to attend to this stimulus. The other picture (or pictures) in the display is designated by the E as incidental or task-irrelevant and is either not mentioned in the instructions or the S is told to ignore these stimuli.

Generally it has been found that the younger Ss remember the central-incidental stimulus pairings better than the older Ss who in some instances can not correctly match any incidental stimulus with the central stimulus with which it was associated during training. The conclusion has been that the younger Ss process more information than is necessary to perform the central task adequately because of some deficit in selective "filtering" ability (e.g. Hagen, 1967). Older Ss are able to selectively respond to the task-relevant information and to some extent "give-up" task-irrelevant information in favor of central task information. In this regard they are described as more efficient than the younger Ss.

The purpose of the present study was to investigate the role of perceptual discrimination in the development of the ability to selectively process information. Since the task-relevant and task-irrelevant stimuli were spatially contiguous in most of the previous studies, it was possible to conclude that the obtained age-related selectivity was attributable to improvement with age in visual discrimination of the two pictures. Two manipulations of discriminability were employed: 1) the task-relevant and irrelevant pictures were spatially separated, and 2) the pictures were positioned so that the necessity for visual scanning was minimized. It was expected that increasing discriminability via spatial separation and stimulus placement minimizing visual scanning would improve performance in selective attention, especially for younger Ss.

The present study also explored the age-related differences in another manner not previously used in past studies -- a posttest questionnaire was administered to each S to obtain information about individual learning strategies.

Method

Subjects: The Ss were 240 children selected from grades four, six and eight of elementary schools in the Detroit, Michigan Catholic school system. There were four treatment groups within each of the three grade levels. An approximately equal number of boys and girls were assigned to each of the groups. All groups were equated for intellectual ability on the basis of scores on the California Test of Mental Maturity (CTMM). A high degree of similarity between group IQ scores was achieved. The range of group means was only seven points. The mean scores by grade level were as follows: fourth grade -- M = 101.2, SD = 11.0; sixth grade -- M = 104.0, SD = 14.7; and eighth grade -- M = 103.2, SD = 14.5. The Ss in this study, most of whom were Negro, came from inner-city, working-class backgrounds.

Memory task: A memory task described by Hagen (1967) was administered to each S individually. Briefly, there were two parts to the task. The central task consisted of a display of six cards, which were mounted on a grey cardboard panel measuring 8.5" x 28". Each card, measuring 3" x 6", contained two black line drawings. Each of the two draw-

ings or pictures was an instance of each of two categories -- an animal and a household object. The same two pictures always appeared together on the same card.

Each S was shown an array of six cards for six seconds. At the end of the six-second interval, the array was covered with another grey cardboard panel on which the six locations were outlined in black. The S was then shown a duplicate of one of the cards he had just observed and was asked to point to where he saw that card. After the S pointed to the location he thought was correct, the array was briefly shown again so that the S could see whether or not he located the picture correctly. This part of the procedure was designed so that a uniform amount of exposure to the incidental cues was given to all Ss regardless of their score on the central task. There were eight stimulus arrays. The S's central memory task score was the number correct out of the eight trials.

The incidental task was administered after the eight central task trials. For this measure, the animal pictures were prepared on 3" x 6" cards with the animal placed in the same position it actually occupied on the card in the central memory task. The household objects were prepared as individual cut-outs which were placed before the S. He was asked to match the household objects with the animals with which they had always appeared. The six animals were shown one at a time, and the household object was placed back in the array in front of the S so that he was choosing from an array of six items each time. The score for the incidental task was the number correctly recalled of the six.

Experimental groups: Discriminability between relevant and irrelevant items on each card was varied by changing the position of the two stimuli along the dimensions of spacing and alternation. In two of the experimental conditions the animal picture was spatially separated from the household object on each card. In the other two experimental conditions both stimulus pictures were contiguous. The spaced condition was assumed to be the more discriminable of the two.

Discriminability was modified in a second way. In one spaced and one contiguous condition all the animal pictures in a sequence were in the top position on the card and the pictures of the household objects were in the bottom position. This constituted the non-alternated condition. In the remaining spaced and contiguous conditions, the two

stimuli were randomly alternated with respect to placement at the top or bottom of the card. For example, within an array of cards, on four cards the animal picture could appear at the top of the card and on the remaining two cards, at the bottom. These groups constituted the alternated condition. There were, therefore, four experimental conditions: Contiguous-Alternated (CA), Contiguous-Non-alternated (CN), Spaced-Alternated (SA), and Spaced-Non-alternated (SN).

Questionnaire: All Ss were asked a series of questions after the incidental recall task. The inquiry was designed to obtain information about the Ss' manner of approaching the task.

Ss were first asked if they expected to be tested on the household object-animal pairs in order to eliminate those children who purposely rehearsed the incidental task. The results from the questionnaire were coded into five categories. The data were examined to determine a) rehearsal sequence, whether orderly or random; b) type of verbal encoding, whether relevant or irrelevant item labels; c) tendency to make thematic connections between relevant and irrelevant items, whether present or absent; and d) kind of visual scanning strategy, whether the whole card or parts of it.

Procedure: Each S was given a practice trial involving pictures that never actually appeared on the test cards. The S was instructed to look at the animals and to remember where each one was in the row of cards. The practice card was covered with a blank panel and the S was asked to point to where a particular animal was located. The instructions were repeated if the child did not understand them at first. Trials 2 and 6 were four-card arrays; the rest were six-card displays. The six picture-pairs appeared in randomly varying positions with no picture-pair appearing more than twice in the same position. The four-card arrays were included after pre-testing indicated that six-card arrays might result in a very difficult task for the youngest CA Ss.

Results

Central and Incidental Recall Scores: The results of major interest were the recall scores for the central and incidental tasks. Figures 1 and 2 present mean recall scores

for the three grade levels and four treatment groups. Figure 1 shows that correct performance for the central task generally increased as a function of CA. A three-way analysis of variance for grade level, spacing, and alternation was performed. Grade level produced the only significant main effect ($F = 12.31$, $p < .01$). There was also a significant interaction between grade level and alternation ($F = 3.07$, $p < .05$). Individual comparisons, however, revealed that the differences between alternated and non-alternated groups at fourth and eighth grades were not significant.

Scores for Ss in the CA, SA, and SN conditions followed the pattern obtained in past studies, i.e. a linear increase with age. The CN condition deviated from this pattern -- the mean sixth grade score was lower than the mean fourth grade score -- however, this difference was not significant ($F < 1$).

Insert Figs. 1 and 2 about here

In Figure 2 it can be seen that incidental recall was clearly affected by modifications in stimulus arrangement. The first point to be noted is that the curve for Condition CA closely resembled those obtained from previous studies. An analysis of variance for grade, spacing, and alternation revealed that the spacing condition resulted in the only significant main effect ($F = 26.11$, $p < .001$); thus the assumption that separating the relevant and irrelevant stimuli increases discriminability was supported. The Grade x Spacing interaction was not significant ($F < 1$), contrary to what would be expected if younger children had poorer visual discrimination.

The assumption that non-alternation of stimuli would enhance discriminability was not borne out in the analysis of incidental recall scores, i.e. alternation was not a significant main effect.

Incidental as Percent of Total Information: The data from Figures 1 and 2 were analyzed in another manner to illustrate more clearly the developmental changes in selective information processing. Central and incidental recall scores were added together to produce a score that represented the total amount of information processed. In this way

the average total number of remembered items was computed for each treatment group at the three grade levels. Incidental recall scores were then divided by the total information score to yield a measure of the proportion of incidental information processed relative to the total amount of information processed. These data indicated that the proportion of incidental information declined with age. In all four treatment groups there was a drop in percentage scores between the sixth and eighth grades. The sharpest overall decrease was in the condition assumed to be most discriminable -- spaced and non-alternated, SN.

Central-Incidental Scores as Repeated Measures: A four-way analysis of variance, with central and incidental recall scores as the repeated measure, was performed in order to investigate possible interactions between the two kinds of recall measures across grade level and treatment conditions (Extension of Case II -- Winer, 1962, p. 337). Since the maximum number correct differed for central and incidental tasks, raw scores were converted to the proportion correct for each S. The results of the analysis indicated that only two interactions were significant: Grade x Central-Incidental ($F = 7.86$, $p < .01$) and Spacing x Central-Incidental ($F = 13.04$, $p < .01$). The significant interaction between grade and type of recall measure replicates a finding of earlier studies (Maccoby and Hagen, 1965; Hagen, 1967) and confirms the prediction that central and incidental information are processed differently at different age levels. The significant interaction between spacing and central-incidental scores suggests that increasing discriminability had a differential effect on the two performance measures. Only incidental performance was significantly affected.

Test Score Correlations: An additional analysis was performed to test Hagen's (1967) notion that incidental information is "traded" for central information. Hagen (1967) obtained negative correlations between performance on central and incidental tasks for his oldest age group, which he interpreted as evidence for the "giving up" of task-irrelevant information for task-relevant information. The fact that the correlation between these two variables was positive at the younger age levels further supported the notion that "trading" of irrelevant for relevant information was an ability that developed

with age. Table 1 contains the correlation coefficients computed between central and incidental recall scores for the combined groups. The majority of the correlations were non-significant; however, the trend was in the direction previously reported, in that relationships at the fourth grade level were positive, near zero at the sixth grade level, and became negative at the eighth grade level. The difference between the overall correlations at the fourth and eighth grade levels was significant ($z = 2.65$, $p < .01$). The decline in magnitude of the correlations between fourth and eighth grades was significant for the spaced groups combined ($z = 3.36$, $p < .001$), but not significant for the contiguous condition. Spacing apparently enhances the "trading" effect.

Insert Table 1 about here

Correlations between central and incidental recall and CTMM scores were computed. There was a consistent, positive relationship between intellectual ability and central task performance for fourth grade Ss ($r = .45$, $p < .05$) and eighth grade Ss ($r = .31$, $p < .05$). No explanation is readily available for the lack of correlation for sixth grade Ss.

The correlations between incidental scores and CTMM scores were small and insignificant. The average coefficients for the three grades were: Grade four, $r = .02$; grade six, $r = .16$; grade eight, $r = .14$. The data thus indicate that central and incidental task performance are not related to general intellectual ability in the same manner.

Questionnaire Responses: The responses to the questionnaire were examined by grade level and by experimental treatment condition. By observation it was apparent that the distribution of responses was nearly identical for all four treatment groups; therefore, no further analyses were made by treatments. Differences in responses between grade levels for two of the categories proved revealing; they are presented in Figures 3 and 4.

Insert Figs. 3 and 4 about here

Figure 3 shows that with increasing age there was a progressive rise in the tendency to rehearse by saying only the names of the task-relevant items and a progressive decline in the tendency to say the names of irrelevant items. The frequencies of responses to all of the possible categories concerning type of verbalization were tabulated and a Chi-square analysis indicated that the distribution was significant ($\chi^2 = 12.74$, $p < .02$).

From Figure 4 a similar pattern in reported visual scanning strategies can be discerned. More older Ss than younger Ss reported that they tried to look at only the relevant item when perusing the cards. With increasing age there was also a progressive decline in the tendency to notice both stimulus items on every trial. The distribution of frequencies was significant by Chi-square analysis ($\chi^2 = 19.47$, $p < .001$).

From the remaining questionnaire categories it was learned that rehearsal sequences do not change appreciably with increasing age. Approximately 80 percent of the Ss at all grade levels initially surveyed the array of stimuli in an orderly right to left, or left to right, sequence. Approximately 70 percent of Ss at all grade levels reversed their original sequence when they perused the same array a second time. The tendency to make thematic connections between the stimuli also did not change significantly as a function of age. Approximately 20 percent of all Ss verbalized some kind of a thematic connection between the relevant and irrelevant items on either all or some of the cards.

Sex Differences: Three-way analyses of variance were performed on both central and incidental scores to investigate the significance of sex differences. For the incidental recall scores, the sex differences were not significant ($F < 1$). For the central scores, sex differences were significant ($F = 5.99$, $p < .05$) although none of the interactions reached significance. An inspection of the mean central scores revealed that girls tended to have lower scores than boys. This was an unexpected finding since none of the previous developmental studies using the incidental learning paradigm obtained sex differences.

Discussion

The results of the present study clearly substantiate the findings of past research in that central recall scores increased with age while incidental recall scores declined with age relative to the total amount of information processed. Correlation patterns were also replicated in the present study. Positive relationships were obtained between central and incidental scores at the youngest age levels and negative correlations at the oldest age levels. Considering the diverse subject populations and techniques used in the various studies, it can be concluded that the developmental changes observed are replicable phenomena and are generalizable to a wide variety of subject populations.

The hypothesis of improvement with age in visual discrimination led to the prediction that when incidental stimuli can be easily differentiated from central stimuli, younger children should be able to ignore the task-irrelevant items better than when the incidental stimuli are less easily differentiated from the central stimuli.

The results indicated that making the stimuli more discriminable significantly improved the performance of older Ss; however it did not necessarily lead to less processing of incidental information by the younger Ss; therefore the hypothesis of a perceptual deficit in younger children was not confirmed.

An alternative explanation based on the notion of superior encoding strategies in older Ss can be supported by the data from the posttest questionnaire.

Underwood (1963) has observed that the adult S often deliberately chooses certain characteristics of the stimulus complex as the cue to which he responds. "Generally speaking, the college sophomore will use the minimally necessary differentiating component for the functional stimulus. He minimizes stimulus redundancy" (Underwood, 1963). From the data in the present study one can conclude that this tendency probably develops between 10 and 13 years of age.

Gibson (1963) has argued against the use of the term "need for redundancy" in describing the younger child's apparent responsiveness to multiple cues. Gibson prefers to look at the issue in terms of the child's need "to learn to select and enhance for himself the critical features and to disregard the noisy and redundant ones." The strategies

revealed by the questionnaire might be the skills involved in making distinctions between critical and redundant cues.

Additional evidence for superior processing strategies in older Ss came from the fact that central task recall scores were not significantly affected by the spaced conditions. Hagen (1967) found that a second picture on a card acted as a "distractor" since central scores were higher when there was only one picture on each stimulus card. In the present study, the incidental picture on each card acted as a distractor even when it was spatially separated from the central picture since central scores were not higher in the spaced conditions. Incidental scores, however, were lower in the spaced conditions, especially for the older age groups. It can be concluded therefore, that all Ss were distracted by the irrelevant stimuli, but younger Ss more often continued to process this kind of information.

Haber (1966) observed that in experiments with adults "the effectiveness of attention instructions depends on whether the S's encoding strategy is susceptible to such a manipulation." From the present data it could be concluded that older children employ an encoding strategy that permits them to focus more exclusively on the relevant stimuli when instructed to do so. The attention instructions are probably not effective with the younger Ss because their strategies predispose them to attempt to encode all the items they perceive.

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Footnote

[1]Currently at the Veteran's Administration Hospital, Allen Park, Michigan. This study was conducted while the first author was a USPHS Predoctoral Research Fellow. The excellent cooperation of the following Detroit, Michigan schools was greatly appreciated: St. Agnes, Blessed Sacrament, St. Bernard, Our Lady of Sorrows, and St. Anthony.

Table 1

Correlations between central and incidental task scores for three grade levels and four stimulus conditions

Condition	Grade		
	IV	VI	VIII
Combined Groups			
Contiguous (CA + CN)	.07	.04	.05
Spaced (SA + SN)	.32*	.08	-.41*
Alternated (CA + SA)	.31*	.19	-.04
Non-alternated (CN + SN)	.06	-.06	-.32*
Average Across Groups	.24*	.06	-.18

*$p < .05$

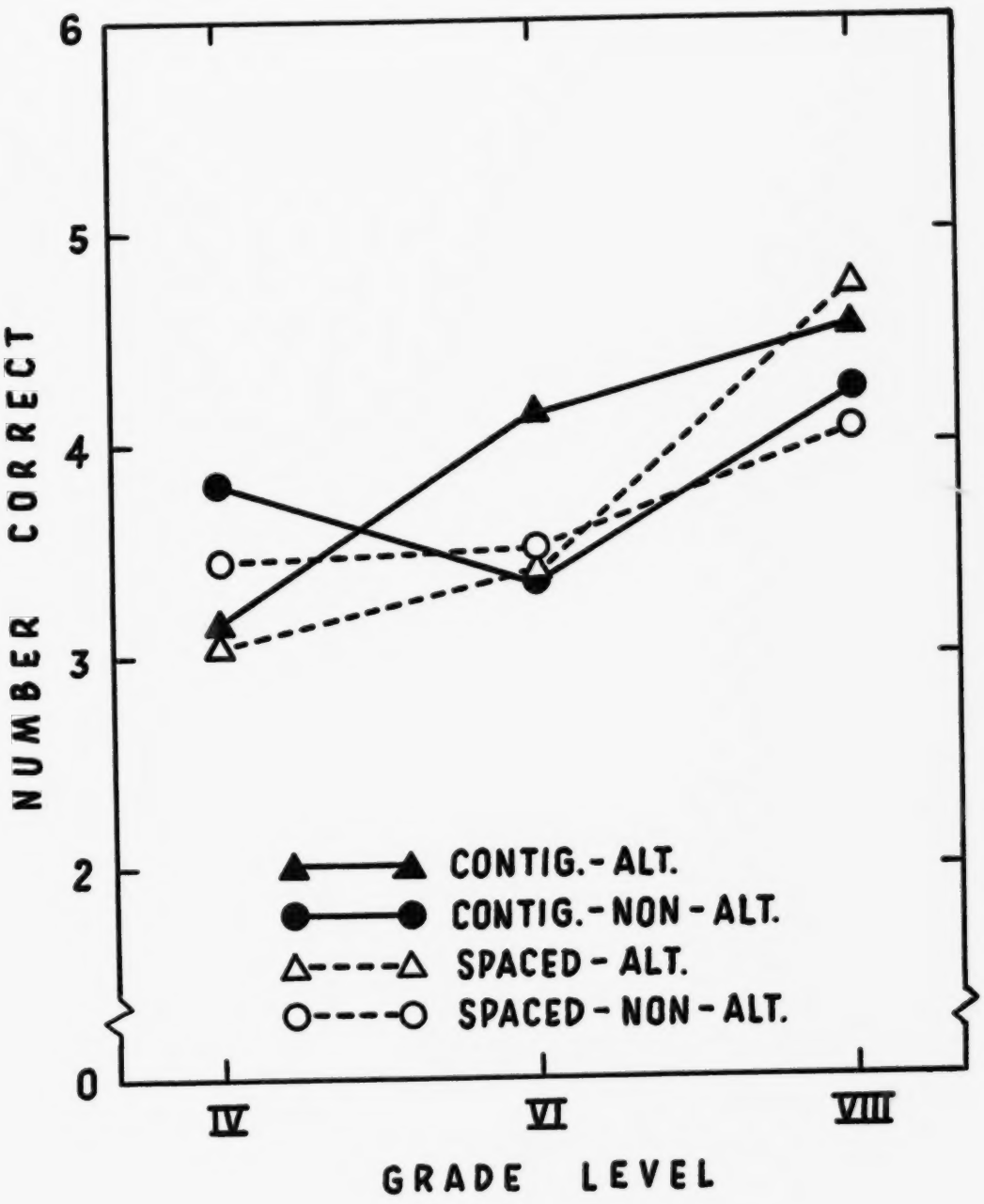

Figure 1. Central Task Recall Scores for Three Grade Levels and Four Stimulus Conditions

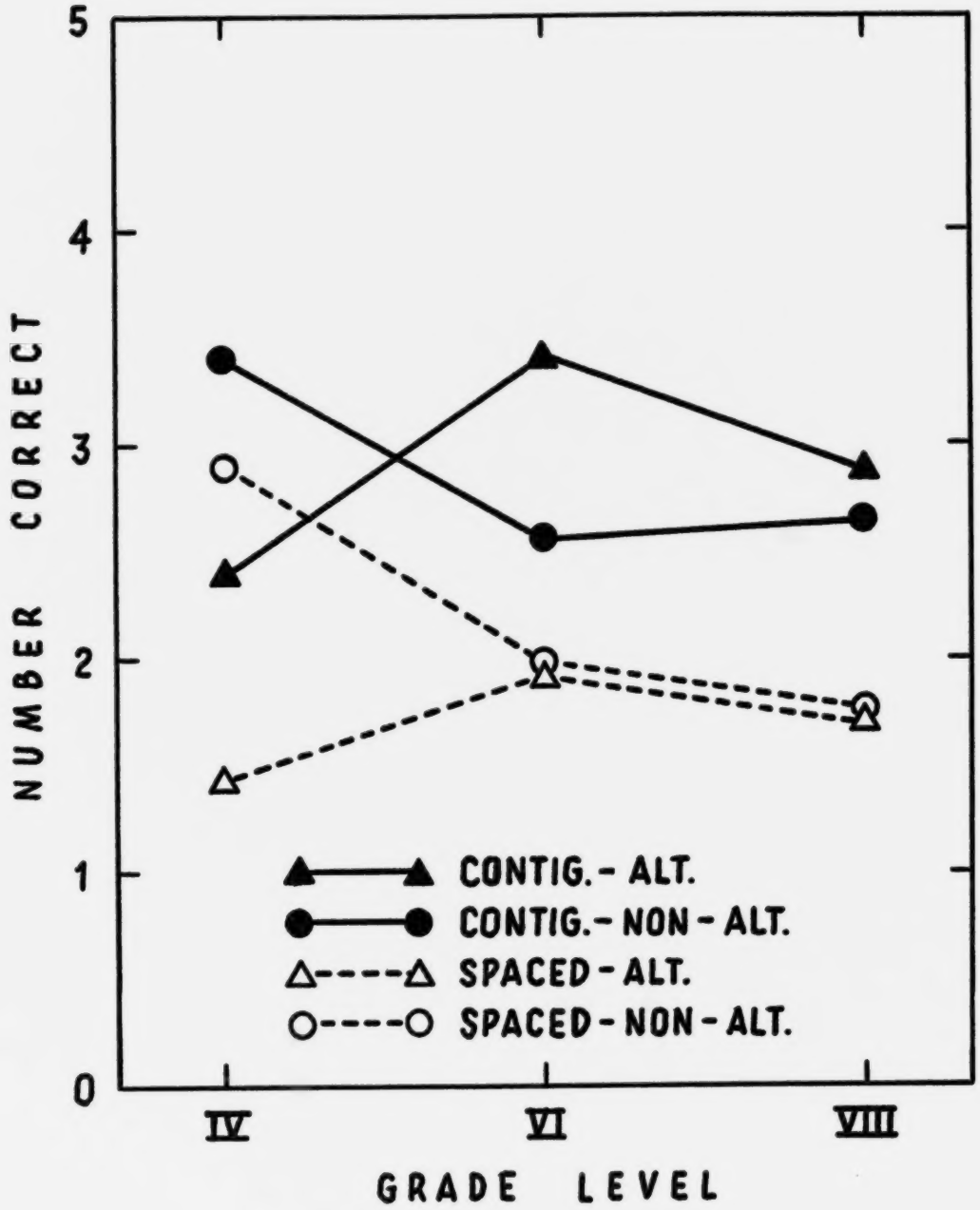

Figure 2. Incidental Task Recall Scores for Three Grade Levels and Four Stimulus Conditions

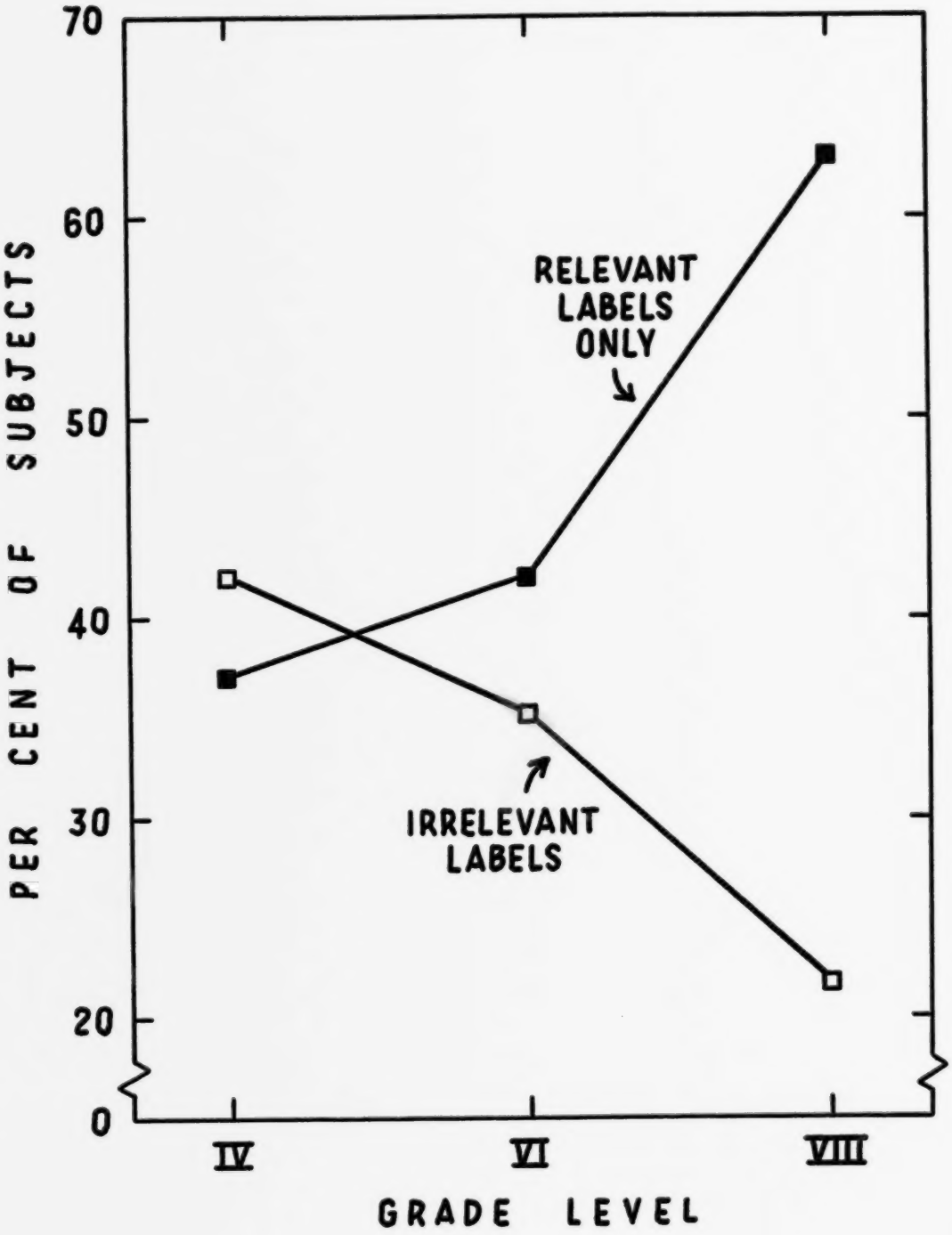

Figure 3. Percent of Subjects Reporting Use of Relevant vs. Irrelevant Labels During Implicit Rehearsal For Three Grade Levels

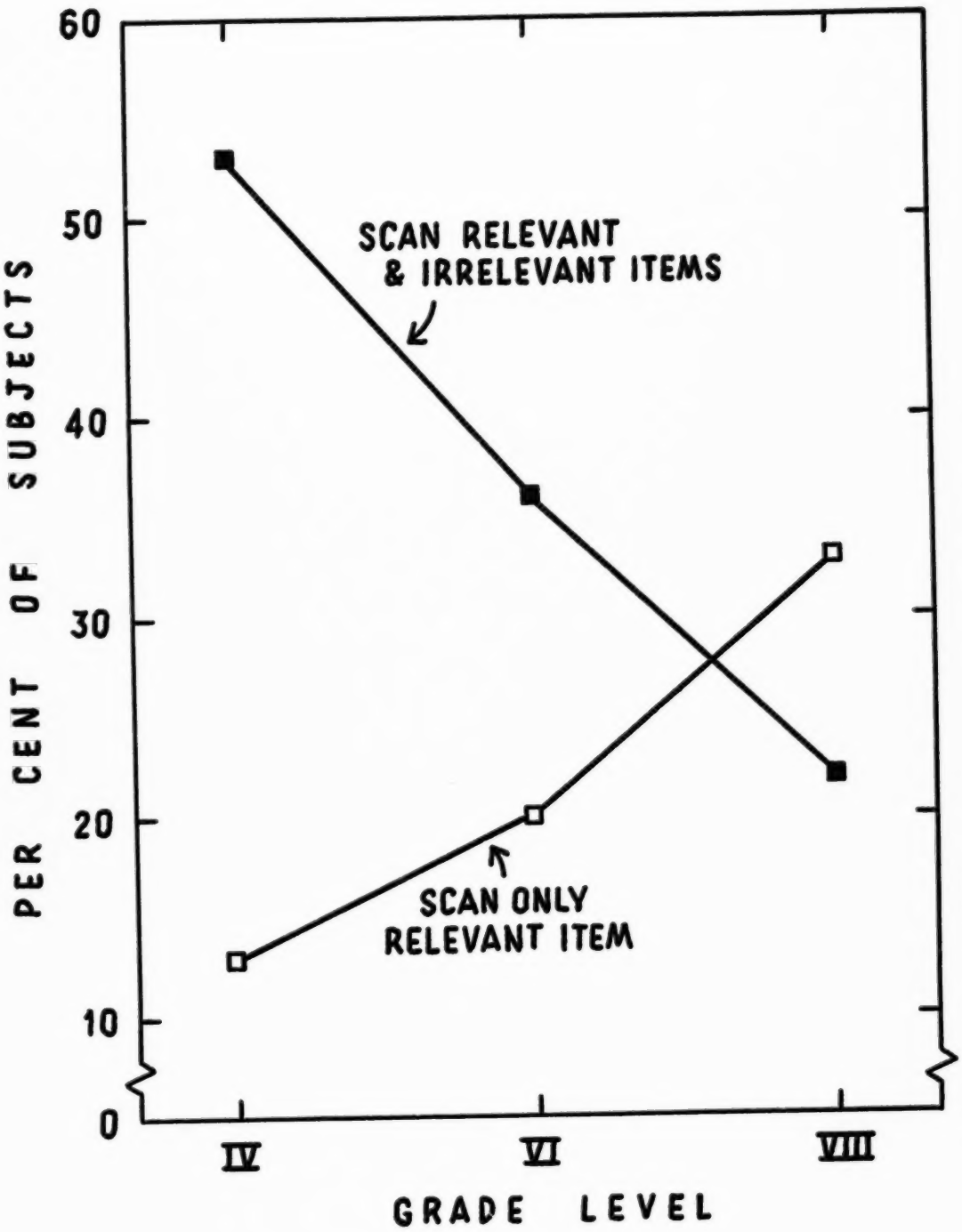

Figure 4. Percent of Subjects Reporting Amount of Visual Scanning for Three Grade Levels